THE HOT SPRINGS AT THERMOPOLIS, WYOMING[1]

N. H. DARTON

At the southern end of the Bighorn Basin there is a great hot spring which presents some notable geologic features and an interesting question as to the source of the hot water. The spring is at the town of Thermopolis, a village and health resort which owes its existence largely to the reputed therapeutic value of the water. The locality is on the bank of Bighorn River, a few miles north of a high range which may be regarded as the southwestern continuation of the Bighorn Mountains. There are several springs, but one of them has by far the greatest volume. They issue from the red beds, here brought to the surface by a prominent local anticline. The present springs and their predecessors—for the region has been one of thermal activity for many centuries—have built extensive terraces of travertine or hot spring deposits similar to some of those in the Yellowstone National Park.

The geologic structure at Thermopolis is relatively simple and, owing to the extensive exposures of the formations, it is perfectly plain. The cross-section (Fig. 1) shows the relations from the crest of the Bighorn uplift in the mountain summit 10 miles south to a point a few miles north of the springs.

South of the springs there is the long monocline constituting the north slope of the anticline of Bighorn Mountains, and in the vicinity of Thermopolis this monocline is crenulated by a sharp anticline. The axis of this flexure crosses Bighorn River a short distance north of Thermopolis, and along it there are exposed the Chugwater red beds, while on either side is a succession consisting of Sundance (Jurassic), Morrison, Cloverly ("Dakota"), and Benton formations. The dips on the south limb of the anticline are steep, 50° to 65°, while those on the north side are gentle. The Cloverly sandstone on either side gives rise to a prominent "hogback ridge,"

[1] Published with permission of the Director of the U. S. Geological Survey.

as shown in the distance in the upper view in Fig. 2, facing a region of red bed hills about a mile wide and with outer slopes descending into valleys of Benton basal shales. Thermopolis is on the eastern limb of the anticline, the village extending across the outcrop zones of the Sundance, Morrison, and Cloverly formations, locally covered by an alluvial plain which extends back a few hundred rods from the river. There is no evidence of igneous rocks in the region.

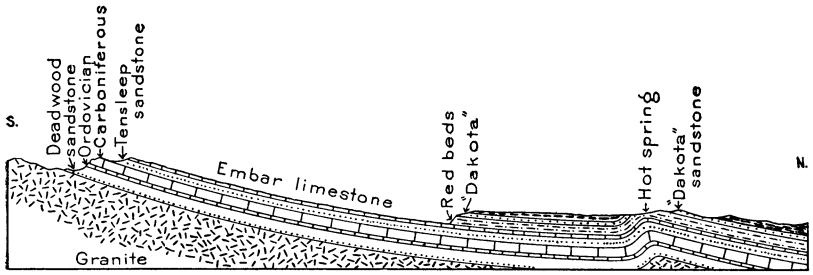

FIG. 1.—Section through the hot springs at Thermopolis, Wyo. Looking west. Length of section about fourteen miles.

The springs rise from the middle beds of the Chugwater formation, apparently through a number of deep cracks. The largest one issues from the foot of a high bank of 80 feet of red sandstones, as shown in Figs. 2 and 2*a*, with a volume stated to be over a thousand gallons a second. The water is clear and hot, having a temperature of 135°. It flows over a wide terrace built of hot-spring deposits, over the edge of which it falls into the river. A part, however, is diverted into conduits of various kinds which lead to the various bathhouses, and to the reservoirs in which a portion of the water is cooled so that it may be used for diluting the hot water to the required temperature for bathing. The spring flows with great force, and evidently comes from considerable depth under high pressure. Numerous algæ of various colors grow in the hot and cooling water, as in the Yellowstone Park and other places. Besides the main spring, there are on the east side of the river a deep, hot pool which does not overflow and, some distance farther north, a hot sulphur spring which gushes out of the travertine bank a few feet above the river. On the west side are several small springs, one of which is utilized for a bathhouse and swimming-

pool. An analysis of the water from the great spring, by Professor E. E. Slosson is as follows:

ANALYSIS OF WATER FROM HOT SPRINGS AT THERMOPOLIS, WYO.

	Grains per Gallon
SiO_2	4.986
Fe_2O_3 and Al_2O_3	0.227
K Cl	10.249
Na_2SO_4	15.110
Mg_2SO_4	19.443
Ca SO_4	13.156
Ca CO_3	40.454
Na Cl	26.195
Total	129.820

Hot Spring deposits.—The hot-spring deposits in the vicinity of Thermopolis indicate a long period of accumulation, for they occur on several distinct terraces, some of which date back probably to Tertiary time. The most recent deposits are being laid down on a broad terrace about 30 feet above the river, which is being built up very gradually. No precise estimate has been made of the rate of increase, but objects placed in the water are rapidly coated with the deposit, and a thickness of an eighth of an inch is accumulated in a short time. There are wide areas of the deposit on both sides of the river below the present springs, which were formed at no distant date, while, on the buttes which rise above this terrace level, there are caps of hot-spring deposits at various elevations. Some of the relations of these are shown in Figs. 3 and 4. The highest deposit caps a prominent butte near the cemetery, at an altitude of about 700 feet above the river. A larger terrace remnant remains on a butte which rises immediately west of the river to a height of about 350 feet above the water. It is probable that these terraces represent three distinct stages of deposition, and, although possibly hot-spring action has been continuous since the formation of the first or highest terrace, most of the deposits at intermediate levels have been removed. As travertine is often deposited on slopes, it is possible that the hot-spring waters issuing at the level of the higher buttes flowed to somewhat lower levels, with a continuous

deposit from one to the other. It is evident, however, from the relations that there has been extensive erosion since the earliest period marked by the higher terraces on which the travertine caps are now found. The high butte near the cemetery—the one shown to the left in Figs. 3 and 4—is probably the remnant of a much

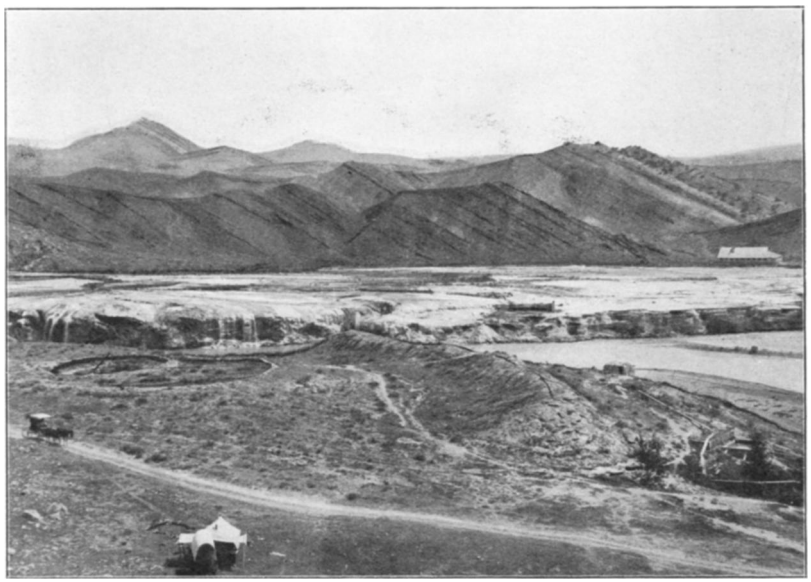

FIG. 2.—Travertine terrace of the Great Hot Spring on the east bank of Bighorn River near Thermopolis, Wyo. The spring is under the *S*. In the foreground are extinct hot-spring craters and a low ridge with long fissure in its summit. Shows upturned red beds and overlying formations.

more extended sheet of the travertine which was largely removed prior to or during the development of the lower terraces.

It is evident, from the disposition of the material, that the springs have shifted their position, but in general the outflow has been in the immediate vicinity of the crest of the anticline. The hot-spring deposits show remnants of numerous hot-spring craters and cracks, some of the most marked of which are on the terraces near the river. On the west bank, a short distance north of the bathhouse, there is an empty crater 30 feet in diameter, shown in Fig. 2, indicating the former existence of a large hot pool, and there is another similar

crater of still larger size, a short distance northeast of the sulphur spring on the east bank. One of the same character, but much less distinct, is found on the high terrace west of the cemetery 500 feet above the river. It is probable, from the present appearances

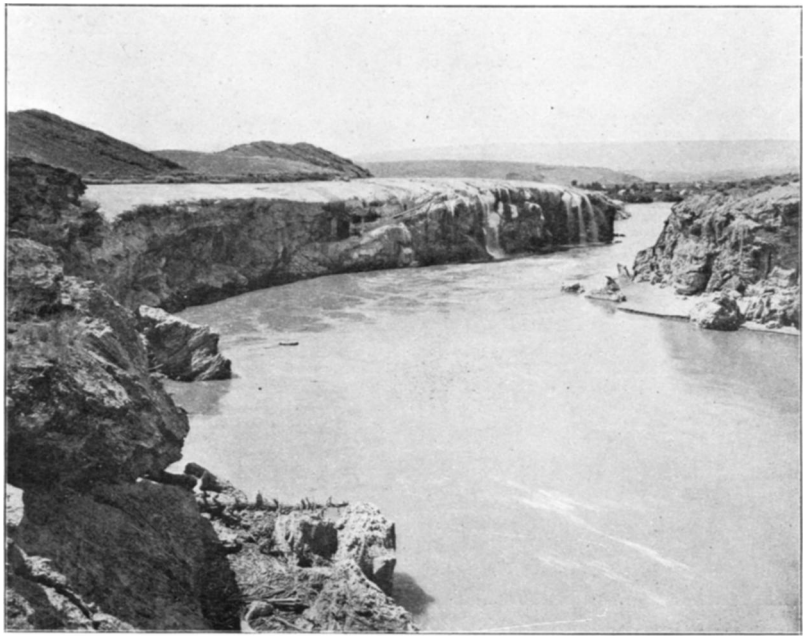

FIG. 2a.—Terrace of hot-spring deposit on the bank of Bighorn River. Looking south to Thermopolis, with Owl Creek Mountains in the distance. Shows overflow of hot spring.

of the deposits, that formerly the hot-spring activity was much greater than at present. Whether or not there were geysers is difficult to state, but some of the features of the deposits strongly suggest

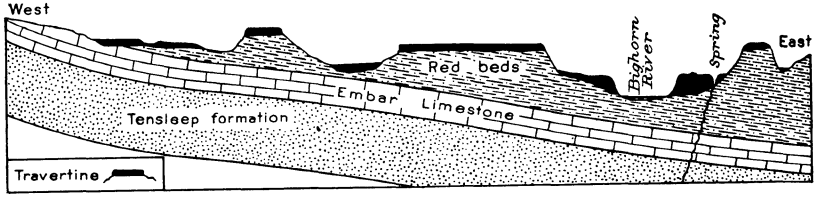

FIG. 3.—Cross-section of travertine terraces a short distance north of Thermopolis, Wyo. Looking north. Length of section about one mile.

that if the water was not thrown out by geyser action, it at least flowed in large volume.

Source of the water.—The source of the water in the Thermopolis springs is difficult to ascertain, but undoubtedly the flow is not derived from the adjacent Red beds, nor from the underlying Embar limestone. Probably the strata are somewhat fractured in the

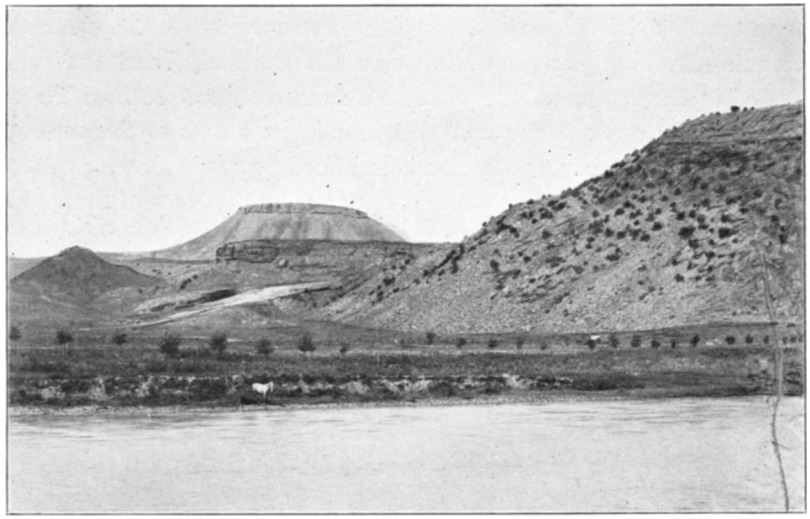

FIG. 4.—Hot Spring deposits on old terraces at various heights in western part of Thermopolis, Wyoming. Looking south across Bighorn River.

crest of the arch and permit the escape of the water from deep-seated sources. One of the most likely of these might be thought to be the porous Tensleep sandstone which outcrops high on the mountain slopes southward. It undoubtedly carries a water supply which passes beneath the syncline south of Thermopolis, and retains sufficient head to rise to and above the surface in any vent to the northward. If the water is from no greater depth than this horizon, there is difficulty in accounting for the high temperature, for the top of the sandstone does not lie at a greater depth than 500 feet at the spring and 2,000 feet in the bottom of the syncline a short distance south. Assuming that the mean annual temperature at Thermopolis is 50°, and that the temperature of water increases one degree for every 50 feet underground below

the first 50 feet—where the mean annual temperature is the underground temperature—a depth of 4,300 feet would be required for the spring water to become heated to 135° under ordinary conditions. As the granite probably lies only 2,500 feet below the spring, or 4,000 feet below the surface in the syncline south, this rate of increase would indicate a source at least as low as the base of the Deadwood formation. If the water is derived from the basal sandstone of that formation, it passes underground in the outcrop area in the high mountain slopes to the southeast, and becomes heated in the bottom of the syncline a short distance south of Thermopolis. In order to preserve this heat in its course to the outlets, there must exist cavernous channels affording rapid flow, as heat would be lost in slow percolation through the interstices of the rock. It is possible also that the source of the water is much less deep, and the heat may be due to deep-seated igneous rocks in this vicinity, which have not yet cooled. As the nearest outcrops of igneous rocks are in the Shoshone Mountains 40 miles west, it appears improbable that there are any intrusions under the Thermopolis region.